

MATERIAL FACT SHEET ROTENONE

MATERIAL NAME: Rotenone

MATERIAL TYPE: Botanical

U.S. EPA TOXICITY CATEGORY: Lower concentration forms are category III, "Caution." Some formulations are category I, "Danger-Poison."

USDA – NOP STATUS:

Considered nonsynthetic, allowed. Preventive, cultural, mechanical and physical methods must be first choice for pest control, and conditions for use of a biological or botanical material must be documented in the organic system plan (NOP 2000).

ACTIVE INGREDIENT DESCRIPTION: Rotenone is a pesticidal compound found in several subtropical leguminous shrubs of the genera Derris, Lonchocarpus, and Tephrosia.

HOW IT WORKS: Rotenone is a slow-acting poison which interferes with the electron-transport system in the mitochondria. It acts as both a contact and stomach poison.

TYPES OF PESTS IT CONTROLS: Rotenone is toxic to many species of insects in many different insect orders (caterpillars, beetles, flies, etc.). It also kills fish and ticks.

FORMULATIONS AND APPLICATION GUIDELINES:

Rotenone was commonly used by organic growers in the past. However, at this time (2005), no rotenone products have been reviewed for approval by OMRI. However, some formulations, such as dust or wettable powder products may be approved in the future. Dust formulations are best applied in early morning when the wind is still and dew is on the plants. Wettable powders sometimes have been difficult to spray, especially at high rates, due to large particle size.

Liquid formulations may contain piperonyl butoxide (PBO) or solvents that are prohibited under the NOP. Many liquid formulations of rotenone also contain pyrethrum. For pests that need to ingest rotenone for it to work, the pyrethrum/rotenone products would be undesirable, since the contact poison pyrethrum would reduce ingestion.

Information from older studies indicates that in several cases, improved results were obtained when rotenone was sprayed with oils or soaps.

AVAILABILITY AND SOURCES: Readily available from garden and farm suppliers; however no products are known to be currently approved for organic production. Growers will need to obtain complete disclosure of all ingredients in formulated products in order to determine if they meet NOP requirements.

REENTRY INTERVAL (REI) AND PRE-HARVEST INTERVAL (PHI): Do not enter treated area for 12 hours after application. Crops may be harvested one day after application.

APPLICATION TIPS:

Rotenone is rapidly broken down by sunlight so evening spraying may provide best results. Use of UV-inhibiting adjuvants may allow for a longer period of control. Rotenone is extremely toxic to fish. Care must be taken when disposing of any unused spray material or residue in wash water so that it does not enter bodies of water.

EFFECT ON THE ENVIRONMENT:

Leaf persistence. Rotenone is quickly degraded in sunlight (Exttoxnet 1996)

Fate in water. Rotenone compounds are broken down rapidly in water (Exttoxnet 1996)

Soil persistence. Soil application studies of rotenone showed a half-life of only 1-3 days (Exttoxnet 1996).

Wildlife and domestic animals. Rotenone is extremely toxic to fish such as bluegill and lake trout and slightly toxic to bird species such as mallards and pheasants (Exttoxnet 1996).

Rotenone acts as a general inhibitor of cellular respiration. The acute oral toxicity of rotenone is moderate for mammals, but there is a wide variation between species. Rotenone by the oral route is less toxic to mice and hamsters than rats. Pigs seem to be especially sensitive. The reported oral LD50 values rats vary considerably, possibly because of differences in the plant extracts used. Studies have shown that in rats rotenone is more toxic to females than males. It is highly irritating to the skin in rabbits (WHO 1992).

Effect on beneficial arthropods. Rotenone is relatively nontoxic to bees (Exttoxnet 1996). However, it can kill many other beneficial species if they come directly into contact with it.

EFFECT ON HUMAN HEALTH:

In the first half of the 20th century, rotenone was considered a non-toxic alternative to the lead- and arsenic-based pesticides in common use. Later research showed that it was more toxic than originally thought. Rotenone

may be absorbed by ingestion and by inhalation. In studies with rabbits, absorption through the intact skin was low (WHO 1992).

Fate in humans and animals: Absorption in the stomach and intestines is relatively slow and incomplete, although fats and oils promote its uptake. The liver breaks down the compound fairly effectively. Animal studies indicate that possible metabolites are carbon dioxide and a more water-soluble compound excreted in the urine. Studies indicated that approximately 20% of the applied oral dose (and probably most of the absorbed dose) may be eliminated from animal systems within 24 hours (Exttoxnet 1996).

Acute toxicity: Local effects on the body include conjunctivitis, dermatitis, sore throat, and congestion. Ingestion produces effects ranging from mild irritation to vomiting. Inhalation of high doses can cause increased respiration followed by depression and convulsions. The compound can cause a mild rash in humans and is a strong eye irritant to rabbits. The oral LD50 of rotenone ranges from 132 to 1500 mg/kg in rats. The reported LD50 of rotenone in white mice is 350 mg/kg. A spray of 5% rotenone in water was fatal to a 100-pound pig when exposed to 250 cubic centimeters (ml) of the airborne mixture. In rats and dogs exposed to rotenone in dust form, the inhalation fatal dose was uniformly smaller than the oral fatal dose. Rotenone is believed to be moderately toxic to humans with an oral lethal dose estimated from 300 to 500 mg/kg. Human fatalities are rare, perhaps because rotenone is usually sold in low concentrations (1 to 5% formulation) and because its irritating action causes prompt vomiting. The mean particle size of the powder determines the inhalation toxicity. Rotenone may be more toxic when inhaled than when ingested, especially if the mean particle size is very small and particles can enter the deep regions of the lungs (Exttoxnet 1996). Occupational exposure to powdered rotenone containing plant materials has been reported to induce dermatitis, ulcers in the nose, and irritation of mucous membrane (WHO 1992).

Chronic toxicity: Growth retardation and vomiting resulted from chronic exposures of rats and dogs. Rats fed diets containing rotenone at doses up to 2.5 mg/kg for 2 years developed no pathological changes that could be attributed to rotenone. Dogs fed doses of rotenone up to 50 mg/kg/day for 28 days experienced vomiting and excessive salivation, but no decreased weight gain. Dogs fed rotenone for six months at doses up to 10 mg/kg/day had reduced food consumption and therefore reduced weight gain. At the highest dose, blood chemistry was adversely affected, possibly due to gastrointestinal lesions and chronic bleeding. Examination of 35 tissue types revealed only one type of lesion that might have been associated with exposure to the test chemical: lesions of the GI tract (Exttoxnet 1996).

A no observed adverse effect level (NOAEL) of 0.4 mg/kg per day has been determined for rats (2-year study) and dogs (6-month study). In short-term studies on rats, dose-dependent bone marrow atrophy and forestomach lesions were observed (WHO 1992).

In 2000, a study was published showing that rats exposed to continuous intravenous rotenone at a rate of 2-3 ppm displayed degenerative neurological symptoms nearly identical to Parkinson's disease (Betarbet et al. 2000). While the goal of this project was to demonstrate a valuable tool for research into the disease, it raised serious questions about whether exposure to rotenone could lead to neurological damage. This question has not been resolved.

Reproductive effects: Pregnant rats fed 10 mg/kg/day on days 6 through 15 of gestation experienced decreased fecundity, increased fetal resorption, and lower birth weight. Very high maternal mortality was seen at this dose. The 2.5 mg/kg/day dose produced no observable maternal toxicity or adverse effect on fetal development. Fetotoxicity and failure of offspring are reported in guinea pigs at doses of 4.5 and 9.0 mg/kg/day for an unspecified period. Thus reproductive effects seem unlikely in humans at expected exposures (Exttoxnet 1996).

Teratogenic effects: Pregnant rats fed 5 mg/kg/day produced a significant number of young with skeletal deformities. The effects were not observed at the 10-mg/kg/day level, so the data do not provide convincing evidence of teratogenicity because the effects do not appear to be dose-related. Thus, the evidence for teratogenicity is inconclusive (Exttoxnet 1996). Fetotoxic effects were observed in mice and rats at doses that elicited adverse reactions in the mother. There were no indications of a teratogenic action in rodents below doses that were maternally toxic (WHO 1992).

Mutagenic effects: The compound was determined to be nonmutagenic to bacteria and yeast and in treated mice and rats. However, it was shown to cause mutations in some cultured mouse cells. In summary, the data regarding the mutagenicity of rotenone are inclusive (Exttoxnet 1996).

Carcinogenic effects: Studies in rats and hamsters have provided limited evidence for carcinogenic activity of rotenone. No evidence of carcinogenic activity was seen in hamsters at oral doses as high as 120 mg/kg/day for a period of 18 months. Studies of two species of rats evidenced no statistically significant cancerous changes in any organ site, including mammary glands, at oral doses of up to 75 mg/kg/day for 18 months. Significant increases in mammary tumors have been reported in albino rats with intraperitoneal doses of 1.7 mg/kg/day for 42 days, and in Wistar rats at approximately 1.5 mg/kg/day orally for 8 to 12 months. In the latter study, however, higher dose rates (3.75 and 7.5 mg/kg/day) over the same period did not produce increased tumors. Thus, the evidence for carcinogenicity is inconclusive (Exttoxnet 1996).

Organ toxicity: Chronic exposure may produce changes in the liver and kidneys as indicated by the animal studies cited above (Exttoxnet 1996).

EPA Status: The EPA last completed a comprehensive review of rotenone in 1988. It is currently under review for re-registration purposes, with comple-

tion of the re-registration eligibility decision scheduled for May 2006. This review will examine current studies examining the potential human health and environmental effects of rotenone, including the recent reports relating to Parkinson's disease. EPA states, "Although studies have indicated that exposure to high concentrations of rotenone may cause adverse reactions, formulations used in and around the home typically contain much lower concentrations of the active ingredient, and are not likely to cause adverse affects." (EPA 2002).

EFFICACY

Older studies: Rotenone is a broad-spectrum insecticide effective against true bugs, caterpillars, beetles, aphids, flies, whiteflies, thrips and leafhoppers (Casida 1973). Within these groups, pests may have a greater or lesser susceptibility to rotenone products. Specific pest species controlled by rotenone as noted in the older literature include: greenhouse whitefly, several aphid species, grape leafhopper, scale and mealybug species, pear psylla, green stinkbug, asparagus beetle, striped cucumber beetle, potato and cabbage flea beetles, Colorado potato beetle, Mexican bean beetle, squash vine borer, cabbage moth species, European corn borer, and blueberry fruitfly/apple maggot fly (Roark 1942-44, McIndoo 1947).

Summary of Older Rotenone Trial Results

Pest Group	Pest	Crop	Consistently good	Variable	Poor
Thrips	Onion Thrips	Onion		x	
Whitefly	Whitefly	Greenhouse	x		
Aphid	Rosy apple aphid	Apple	x		
Aphid	Melon aphid	Melon	x		
Aphid	Cabbage aphid	Brassicas		x	
Aphid	Pea aphid	Pea		x	
Aphid	Potato aphid	Potato	x		
Aphid	Green peach aphid	various		x	
Aphid	Turnip aphid	Brassicas	x		
Leafhopper	Potato leafhopper	Potato		x	
Leafhopper	Grape leafhopper	Grape	x		
Scale	Scale insects	various	x		
Mealybug	Mealybugs	various	x		
Psyllid	Pear psylla	Pear	x		
Bug	Squash bug	Cucurbits		x	
Bug	Tarnished plant bug	various			x
Bug	Green stinkbug	unknown	x		
Bug	Harlequin bug	various		x	
Beetle	Asparagus beetle	Asparagus	x		
Beetle	Striped cucumber beetle	Cucurbits	x		
Beetle	Potato flea beetle	Potato	x		
Beetle	Colorado potato beetle	Potato	x		
Beetle	Cabbage flea beetle	Brassicas	x		
Beetle	Mexican bean beetle	Bean	x		
Beetle	Black vine weevil	unknown			x
Beetle	Plum curculio	Apple, plum			x
Beetle	Japanese beetle	various			x
Caterpillar	Squash vine borer	Cucurbits	x		
Caterpillar	Codling moth	Apple		x	
Caterpillar	Oriental fruit moth	Apple			x
Caterpillar	Grape berry moth	Grape			x
Caterpillar	Moth spp	Brassicas	x		
Caterpillar	Corn earworm	Corn			x
Caterpillar	European corn borer	Corn	x		
Fly	Blueberry fruitfly	Blueberry	x		
	Beneficial Species				
Beetle	Convergent lady beetle		killed 70-82% of adults		

Recent studies: There are insufficient recent studies involving rotenone to summarize here. Six were found using Pyrellin®, a liquid rotenone-pyrethrum formulation (would not be included in a summary of rotenone-only products), and two studies with rotenone powders. They agreed with the older results above, except for one study with poor control of blueberry maggot.

REFERENCE

Betarbet, R., Sherer, T. B., MacKensie, G., Garcia-Osuna, M., Panov, A. V., and Greenamyre, J. T. 2000. Chronic systemic pesticide exposure reproduces features of Parkinson's disease. *Nature Neuroscience* 3 (12):1301-1306.

Casida, J. E., ed. 1973. *Pyrethrum, The Natural Insecticide*. Academic Press, New York.

EPA. 2002. *Controlling Pests with Rotenone*. http://www.epa.gov/oppsr-rd1/REDS/factsheets/rotenone_fs.pdf

Extoxnet. *Rotenone Pesticide Information Profile*. 1996. <http://extoxnet.orst.edu/pips/rotenone.htm>

McIndoo, N. E. 1947. *A Review of the Insecticidal Uses of Rotenone-Bearing Plants, 1938-1944*. USDA Pub. E-713.

NOP. 2000. *USDA National Organic Program regulations, 7CFR 205.206(e)*. <http://www.ams.usda.gov/nop/>

Roark, R. C. *Uses of Rotenone and Rotenoids from Derris, Lonchocarpus (Cube and Timbo) Tephrosia, and Related Plants*. 1942-44. USDA pub. E-579, E-581, E-593, E-594, E-598, E-603, E-625, E-630, E-652, E-654, E-655, and E-656.

WHO. 1992. *World Health Organization. Rotenone Health and Safety Guide No. 73*.